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(71) Applicant *(for all designated States except US)*: **INNOVATIVE SYSTEM DESIGN INC.** [US/US]; Edison, NJ (US).

(71) Applicants and
(72) Inventors: **WAGNER, Lorelei** [US/US]; Edison, NJ (US). **NOCERA, David** [US/US]; 809 Quarry Lane, Martinsville, NJ 08836 (US).

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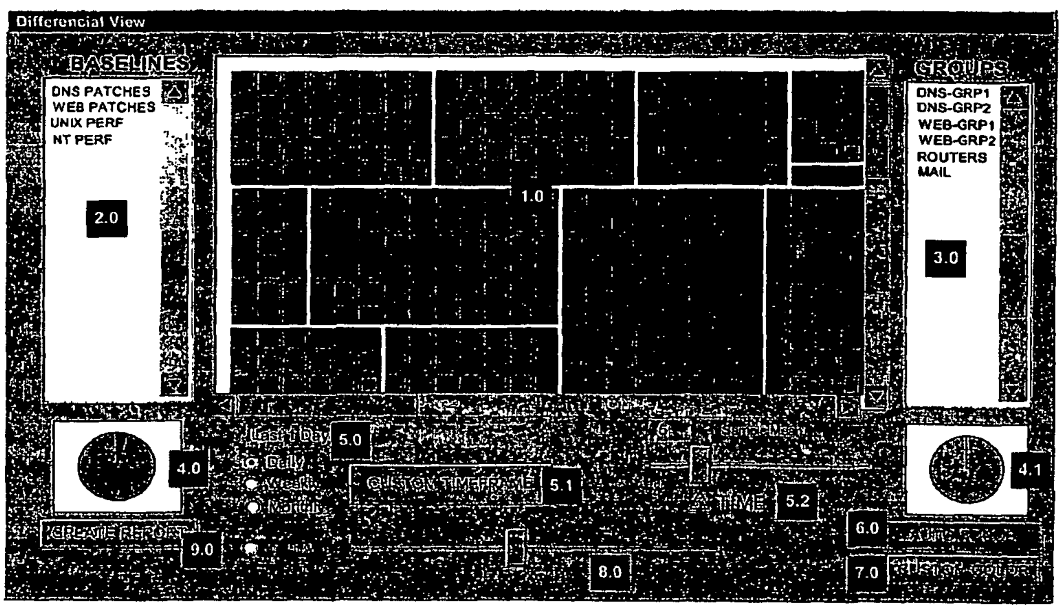
(54) Title: APPARATUS, METHOD, AND ARTICLE OF MANUFACTURE FOR VISUALIZING PATTERNS OF CHANGE AND BEHAVIOR ON A COMPUTE INFRASTRUCURE



(57) Abstract: Provided herein are exemplary techniques for visualizing patterns of changes and behavior on a compute infrastructure wherein a Differential View user interface provides for complete visualization of infrastructure change and behavior and further provides interactive filters that identify and display patterns of change and behavior, on a graduated scale, for the compute infrastructure as a whole and for specific groups within the infrastructure.

WO 2004/040421 A2

TITLE

Apparatus, Method, and Article of Manufacture for Visualizing Patterns of Change and Behavior On A Compute Infrastructure

INVENTORS

David Nocera, Lorelei Wagner

CROSS REFERENCE TO RELATED APPLICATION(S)/CLAIM OF PRIORITY

This application claims the benefit of US Application Number 60/422,005, filed October 29, 2002, which is incorporated in its entirety herein.

This application also relates and incorporates by reference in its entirety International Application Number PCT/US 02/18473, entitled "Apparatus, Method, and Article of Manufacture for Managing Change on a Compute Infrastructure," filed June 11, 2002.

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not applicable.

REFERENCE OF AN APPENDIX

Not applicable.

FIELD OF THE INVENTION

The present invention relates generally to compute and/or network management and more particularly to an improved system, method, apparatus, and article of manufacture for visualizing patterns of changes and behavior on a compute infrastructure such as the one shown in Figure 10.

BACKGROUND OF THE INVENTION

Heretofore, compute infrastructure change visualization techniques involve programmed alerting generated by user defined events on individual technology components or processes. Determining what components have changed and isolating patterns of failure has been the responsibility of the individuals tasked with responding to alarms. As expected, the process is often time-consuming and cumbersome.

Furthermore, the existing focus of alerts on component or process failures undermines the ability of individuals to identify components with a pattern of success.

Accordingly, what is needed is a comprehensive way to visualize change on a compute infrastructure, and more particularly, a solution that detects and presents patterns of both positive and negative change on a compute infrastructure.

SUMMARY OF THE INVENTION

The present invention (also called Differential View) addresses the aforementioned problems of the prior art by providing for, among other things, an improved apparatus, method and article of manufacture for visualizing patterns of change and behavior on a compute infrastructure. Differential View provides for complete visualization of infrastructure change

and behavior and further provides interactive filters that identify and display patterns of change and behavior, on a graduated scale, for the compute infrastructure as a whole and for specific groups within the infrastructure.[1]

Other aspects, features and advantages of the present invention will become better understood with regard to the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring briefly to the drawings, exemplary embodiments of the present invention will be described with reference to the accompanying drawings in which Figures 1-10 graphically illustrate certain aspects and features of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring more specifically to the drawings, for illustrative purposes aspects of the present invention is depicted in the exemplary embodiments generally shown in Figures 1 - 10. It will be appreciated that the illustrated embodiments may vary as to their details, for example, representative icons (a square may be a circle), configuration (the exact screen layout may be adjusted), etc., without departing from the basic concepts disclosed herein. The following description, therefore, should not to be taken in a limiting sense.

High Level Description

[1] This allows any type of compute data to be consolidated and visualized; this view can occur pre- or post- database load, or without ever loading data to a database. Furthermore, the attribute-values may represent any defined test

Figure 1 illustrates a graphical representation of an exemplary embodiment of the present invention. As shown, the graphical view includes several underlying support mechanisms including: Colorized Grid of Nodes[2] (Fig 1 - 1.0): a map of nodes being monitored, grouped for ease of association (in this example, the white lines in the grid divide the nodes by location) colored by evaluation of change status; Baselines (Fig 1 - 2.0): a selection of sets of predefined node attribute values with which to evaluate node conformity; Groups (Fig 1 - 3.0): user defined node groupings for change and behavior pattern isolation; Pie Charts (Fig 1 – 4.0, 4.1): for providing quantitative percentage of change within the selected set of nodes for referential comparison; Time Frame (Fig 1 – 5.0, 5.1, 5.2): utilities from which to alter the time frame evaluated and presented; Auto Focus (Fig 1 – 6.0): a utility which evaluates the groups to present those with the greatest deviation from expected values; Custom Color (Fig 1 – 7.0): a utility to select the colors in which the graduated values for change appear; Rotate (Fig 1 – 8.0): providing view control; Create Report t (Fig 1 – 9.0): a report generator.

Visualization

Figure 2 illustrates the group selection progression of functionality listed in the description of Figure 1. It presents the group pattern identification process which consists of the primary graphical view and supporting mechanisms: Selection of Groups (Fig 2 – 1.0), select the group to be distinguished from the enterprise node view; Identification of Nodes within Group Selection (Fig 2 – 2.0), nodes which belong to the selected Node Group are highlighted to be

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(unit, system, performance, or industrial process).

distinguished from the full population of nodes; Group Selection Pie Chart (Fig 2 – 3.0) provides visualization of the quantitative percentage of change within the selected set of nodes; Node View Pie Chart (Fig2 – 4.0) provides visualization of the quantitative percentage of change in full population to provide a basis with which to compare the group to the whole. This ability provides a means by which to isolate the groups with the highest rate of change. The Auto Focus button (Fig 2 – 5.0) when clicked, will automatically select and present the group with the most significant rate of change.

Figure 3 progresses beyond group selection and into analysis of the group selection through Baseline Comparison.[3] Selection of Groups (Fig 3 – 1.0), select the group to be distinguished from the enterprise node view; Selection of Baseline (Fig 3 – 2.0), select the Baseline through which to filter the node group (this example provides a visualization of nodes in WEB-GRP1 and how they align with the pre-established attribute-value pairs in the WEB-PATCHES Baseline). Node View (Fig 3 – 3.0) presents the group nodes with the status relative to the Baseline; Node View Pie Chart (Fig 3 – 4.0) continually provides visualization of the quantitative percentage of change in full population. Group Selection Pie Chart (Fig 3 – 5.0) provides visualization of the quantitative percentage of change within the baseline for the selected set of nodes (in this example, 100% of WEB-GRP1 exactly match the WEB-PATCHES

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[2] The concept of Node is not limited to a physical object and can be extended to a logical concept like a business process, object or application.

[3] It is not necessary to select a Group in order to select a baseline. One could look at a Baseline for patterns of change or behavior across the enterprise node view; however, patterns are more easily tracked when using both the Baseline and a Group. Figure 3 and 4 combined illustrate the use of Baseline compare to quickly analyze and isolate the set of attributes which are out of range within a Group

Baseline. This would quickly allow a system administrator to dismiss WEB-PATCHES as a problem area and allow him or her to look for other areas in which to find root cause of change.[4]

Figure 4 illustrates the means with which to progress through the Baselines to identify the properties, or patterns, of the most intense change in the infrastructure. The group selected remains as it was in Fig 3, i.e., Web-GRP1. Since, as described in Fig 3, the User learned that the Baseline WEB-PATCHES had no changes, they move to another Baseline in an effort to identify a pattern of the change. Selection of Baseline (Fig 4 – 1.0), select the Baseline through which to filter the node group (this example provides a visualization of nodes in WEB-GRP1 as filtered through the attribute-value associations of NT-PERF). Node View (Fig 4 – 2.0) presents the group nodes with the status relative to the Baseline; Node View Pie Chart (Fig 4 – 3.0) continually provides visualization of the quantitative percentage of change in full population Group Selection Pie Chart (Fig 4 – 4.0) provides visualization of the quantitative percentage of change within the baseline for the selected set of nodes. Comparing the Node View Pie Chart to the Group View Pie Chart indicates quickly that the percentage of change is greater in the NT PERF Baseline than the greater population and indicates an area for further investigation.[5]

Figure 5 depicts the drill down from Figure 4, focusing specifically on the Node Group and Baseline selected at the point the User Drills Down. Node Group View (Fig 5 – 1.0), presents the selected group nodes, delineated by location, with the status relative to the Baseline. The drill-down view reduces the number of nodes in the map, while leaving the remainder of the screen and its corresponding functionality intact.

[4] Multiple Groups may be selected.
[5] Multiple Baselines may be selected.

Figure 6 illustrates alternate 3D views of Drill Down. 3D- Z Axis (Fig 6 – 1.0) is the power axis and can be configured by the User to represent any key aspect of the nodes being monitored (e.g. CPU Power (3of CPUs * CPU Speed), # of Users, Revenue,)

Color

The color assigned to a node is determined using a weighted moving average. Increasing the time of the sampled data for each attribute creates an average. The greater the percentage of change against that average, the greater the deviation and the greater the color shift (e.g. Green to Red).

The delta time is used to compute a moving average for each sample. Time is actually the number of samples back in time, e.g., if the Daily sample is selected (as shown in Figure 6), a delta time of 5 equates to the average of the last five days. The maximum and minimum of the averages are used to compute the entire range of possibility.

For example, if a CPU attribute is selected and it is currently 25%, and the last five days it was: 90%, 10%, 50% 50% and 50%, the min is 10%, the max is 90% and the moving average is (90+10+30+35+50)/5 = 43%. Since 25 is less then 43% it will be on the green scale where 10 is bright green and 43 is the midway point to red. To compute the exact color of green on the scale, 43-10 is 33 and 25-10 = 15, so 15/33 is the percentage of green on the scale. Figure 7 depicts a graphical illustration of this point.

Figure 8 identifies the radio button selections for time comparison (Fig7 – 1.0) Daily, Weekly and Monthly. The timeframe can be customized by using the Custom Timeframe Button

(Fig 7 – 2.0), this customization will allow complex time selections like each Monday between 2 PM and 5 PM. Sliding Sample Mean Time (Fig 7 – 3.0) is used to allow the end user to change the default moving average in the computation of changes for Metrics types of attributes.

User Color Selection

As shown in Figure 9, a user can change the colors in their view according to the user preferences.

Finally, Figure 10 illustrates an exemplary network/compute infrastructure having Managers (Fig 10 - 1.0, 2.0, 2.1, 2.2), Managers with Gateways (Fig 10 - 3.0), Gateways (Fig 1 - 4.0), Managed Nodes with Agents (Fig 10 - 5.1, 5.2, 5.3 etc), Managed Nodes that are Agentless (Fig 10 - 6.0, 6.1, 6.2 etc), Software including application software, that can be managed like a node (Fig 10 - 7.0, 7.1 etc.), and Special Devices that can be managed (Fig 10 - 8.0, 8.1, etc).

CONCLUSION

Having now described embodiments of the present invention, it should be apparent to those skilled in the art that the foregoing is illustrative only and not limiting, having been presented by way of example only. All the features disclosed in this specification (including any accompanying claims, abstract, and drawings) may be replaced by alternative features serving the same purpose, and equivalents or similar purpose, unless expressly stated otherwise. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined by the appended claims and equivalents thereto.

The techniques may be implemented in hardware or software, or a combination of the two. Specifically, the techniques may be implemented in computer programs executing on programmable computers that each include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device and one or more output devices. Program code is applied to data entered using the input device to perform the functions described and to generate output information. The output information is applied to one or more output devices. Each program is preferably implemented in a high level procedural or object oriented programming language to communicate with a computer system, however, the programs can be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language. Each such computer program is preferably stored on a storage medium or device (e.g., CD-ROM, hard disk or magnetic diskette) that is readable by a general or special purpose programmable computer for configuring and operating the computer when the storage medium or device is read by the computer to perform the procedures described in this document. The invention may also be considered to be implemented as a computer-readable storage medium, configured with a computer program, where the storage medium so configured causes a computer to operate in a specific and predefined manner.

CLAIMS:

1. A method for visualizing patterns, such as change, on a compute infrastructure,

a. Wherein any physical or logical concept within can be a node to be monitored for pattern, such as a business process, object or application, embedded devices;

b. Wherein specific colors represent specific pattern conditions;

c. Wherein a range of colors represents a range of pattern conditions;

d. Wherein a combination of range coloration and individual colors are used to denote pattern conditions;

e. Wherein individual elements in a compute infrastructure, called nodes , are monitored and patterns displayed;

f. Wherein individual elements in a compute infrastructure are banded on a map by a set of common groupings, such as location, subnet, business owners etc;

g. Wherein individual elements in a compute infrastructure can be banded together into a logical grouping and studied for patterns. These groupings overlay the individual elements on the map, such that the entire population of nodes can be visualized with respect to the logical grouping;

h. Wherein in studying individual elements or node groupings for patterns, a subset of saved attributes called a Baseline can be used to further qualify and visualize patterns; and

i. Wherein icons can be used to represent nodes (in a general sense).

2. A method for displaying text information on a map,

a. Wherein text is displayed on the icons on the map;

b. Wherein text is assigned based on the value of a single attribute;

c. Wherein text is the result of the output of a function, which takes as input multiple attributes; and

d. Wherein text is a result of the output of a user defined function.

3. A method for grouping nodes within a map,

a. Wherein the association between related nodes (e.g. location, in the preferred embodiment) is identified by grouping them within grid lines; and

b. Wherein a plurality of methods of association is provided (e.g. nodes can be grouped into different grid lines, such as internetworking subnet association, location, business owner, etc.).

4. A method to compare alternate groupings of nodes to one another,

a. Wherein selecting one or more saved node groups, highlights the nodes in that group, so that they can be observed in relationship to the whole population of nodes;

b. Wherein the whole population remains visible;

c. Wherein the nodes in the node group become obvious by means of altering the color of the border around the node;

d. Wherein the nodes in the node group become obvious by means of a 3-dimensional effect, where the nodes in the node group apparently pop-out;

e. Wherein words, color, lines or graphics are used to identify nodes within the node group against the population of nodes; and

f. Wherein the population of nodes patterns in an inverse manner (e.g. highlighting, receding, color pattern etc), so as to draw attention to the nodes in the node group.

5. A graph to identify the percent of pattern of all the nodes in a node group,

a. Wherein the pattern in the overall population of nodes is contained in the pie chart;

b. Wherein only the selected group's pattern is illustrated in the pie chart;

c. Wherein any graph is used to illustrate pattern;

d. Wherein exists an auto focus function, that will automatically select the node group with the most amount of pattern;

e. Wherein exists an auto focus, that will automatically select and sort all node groups, displaying the one with the most pattern on the top, but allowing the user to cycle through all of the choices in rank order of most to least pattern;

f. Wherein exists the ability to customize pattern colors on a global basis; and

g. Wherein exists the ability to customize pattern colors on a per node basis, so that specific nodes have specific color ranges.

6. The method as in any of the preceding claims wherein the pattern can be display as single color representing no pattern, such as green and another single color representing pattern such as red,

a. Wherein the colors are selectable; and

b. Wherein the colors can be selected on a per node basis.

7. The method as in any of the preceding claims wherein the pattern can be displayed as a range of color,

a. Wherein the colors are selectable;

b. Wherein the colors can be selected on a per node basis;

c. Wherein the contribution of individual attributes to the overall color can be controlled by the user such as in a weighted average;

d. Wherein the color displayed is controlled by a number that is returned from a moving average function, whose values indicates the percentage in the color range to display;

e. Wherein the number of samples that go into the moving average is controlled by the user as delta time;

f. Wherein a trade secret algorithm, not fully disclosed, displays the range of color from the rate of pattern, such that, an attribute that is normally high (e.g. CPU 90%) gravitates to green (good) over time, even though the average is high;

g. Wherein the condition to determine the range of pattern is a user defined function, specific to the attribute being tested for pattern; and

h. Wherein the user can determine to what degree the individual attributes contribute to the overall color. This allows individual attributes (e.g. CPU) to have greater impact on the color than less significant attributes (e.g. free pages in memory).

8. The method as in any of the preceding claims wherein the custom timeframes can be selected, allowing the data that is used to contribute to a pattern computation and color display to come from specific recurring times.

9. The method as in any of the preceding claims wherein the baselines are used to contain saved attributes results (e.g. TCP settings and CPU thresholds),

a. Wherein the system functions normally without baselines such as using the last state is the default baseline;

b. Wherein baselines contain all or a subset of the attribute values; and

c. Wherein baselines are used to highlight which nodes (in the general sense) have legitimate values for those attributes. In other words, nodes without legitimate values for attributes defined display differently. For example, nodes without CDROM disks have no legitimate attribute for CDROM Baseline and are turned gray when the CDROM baseline is selected.

10. A pie chart to display the percentage of pattern in a specific Baseline,

a. Wherein the percentage of pattern for all the attributes contained in the baseline is summarized graphically in a pie chart; and

b. Wherein any alternate graph such as a bar chart can also be used to summarize pattern.

11. A drill down capability to limit the size of the population of nodes (in a general sense) being studied,

a. Wherein the drill-down capability exists to limit the display to only the nodes in a group;

b. Wherein the drill-down capability exists to limit the display to only the nodes that contain attributes in one or more saved Baselines; and

c. Wherein exists a mechanism to combine via AND/OR conditions to display drill down from either baselines and node groupings to further limit a population.

12. A method to visualize temporal patterns in data,

a. Wherein the user can view a compute infrastructure only using attribute data from specific timeframes (such as every Monday between 2PM and 4 PM) to either include or exclude from the visualization;

b. Wherein the user can define a function that can customize timeframes, such as every Monday between 2 and 4 PM; and

c. Wherein the user can string together by means of AND/OR conditions multiple functions for define multiple ranges of time from which to exclude or include attribute data.

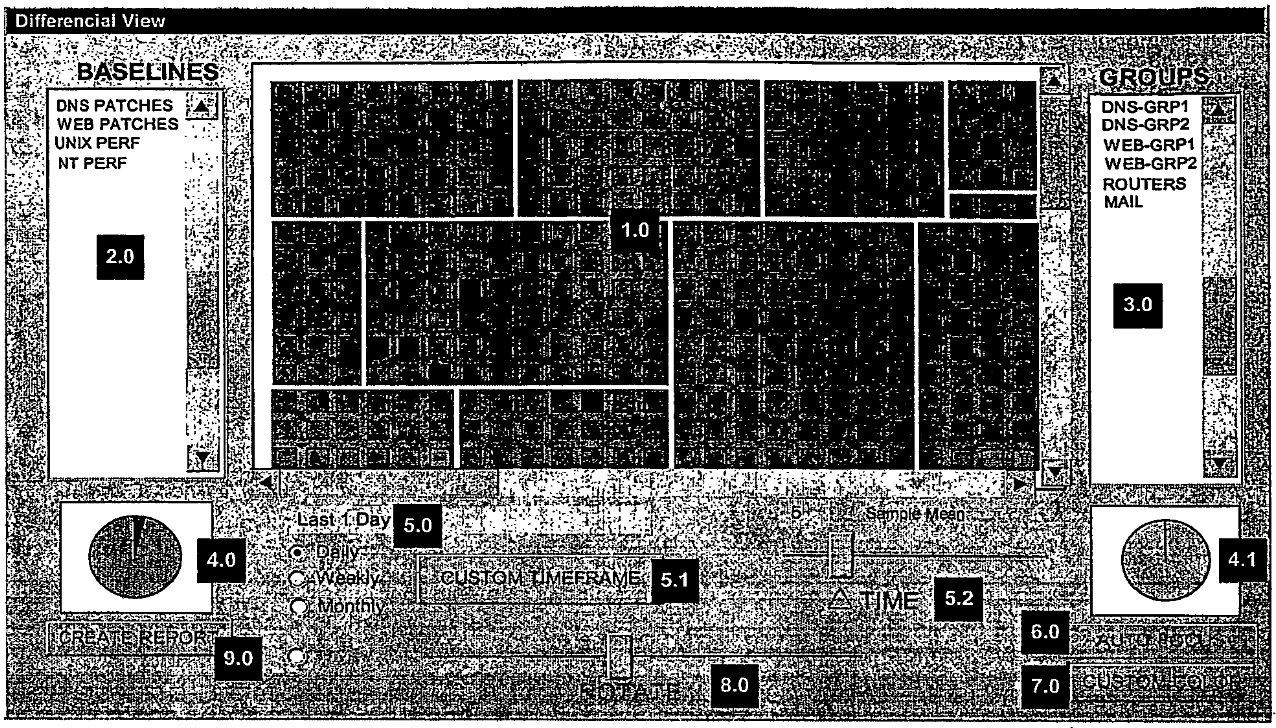

Differencial View
BASELINES
DNS PATCHES
WEB PATCHES
UNIX PERF
NT PERF
2.0
1.0
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
3.0
4.0
Last 1 Day
5.0
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
5.1
Sample Mean
TIME
5.2
4.1
6.0
CREATE REPORT
9.0
ROTATE
8.0
7.0

Figure 1

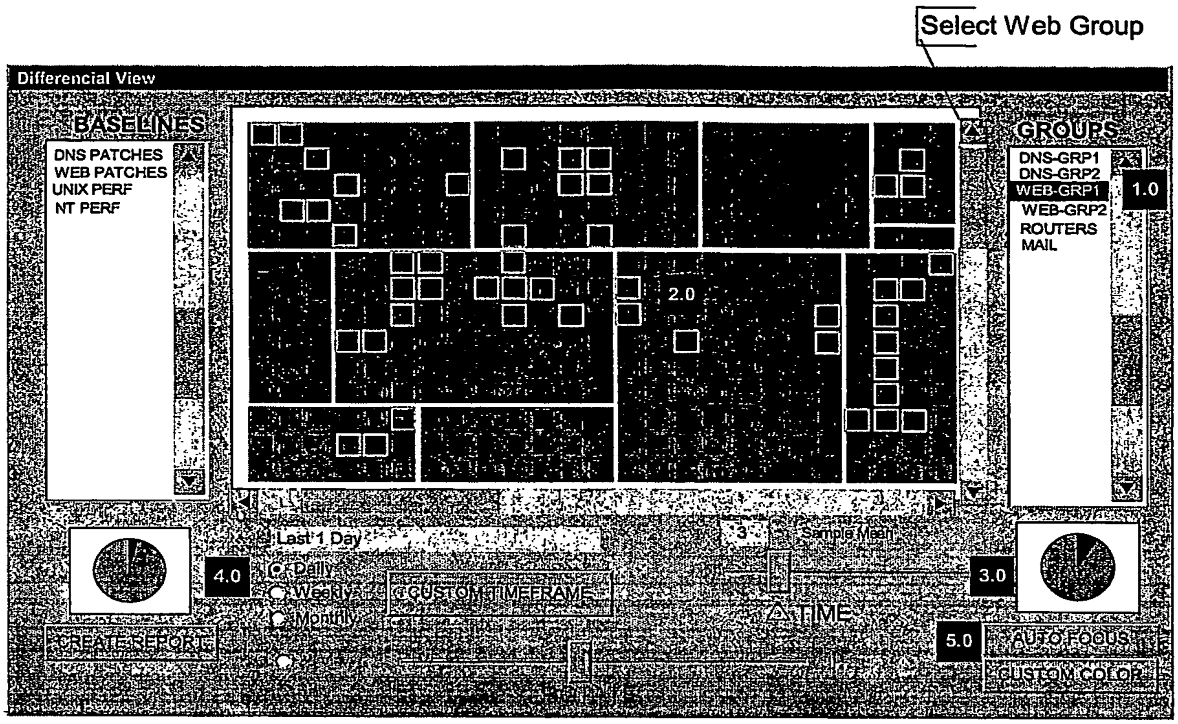

Select Web Group
Differencial View
BASELINES
DNS PATCHES
WEB PATCHES
UNIX PERF
NT PERF
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
1.0
2.0
3.0
4.0
5.0
Last 1 Day
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
3
Sample Mean
TIME
CREATE REPORT
AUTO FOCUS
CUSTOM COLOR

Figure 2

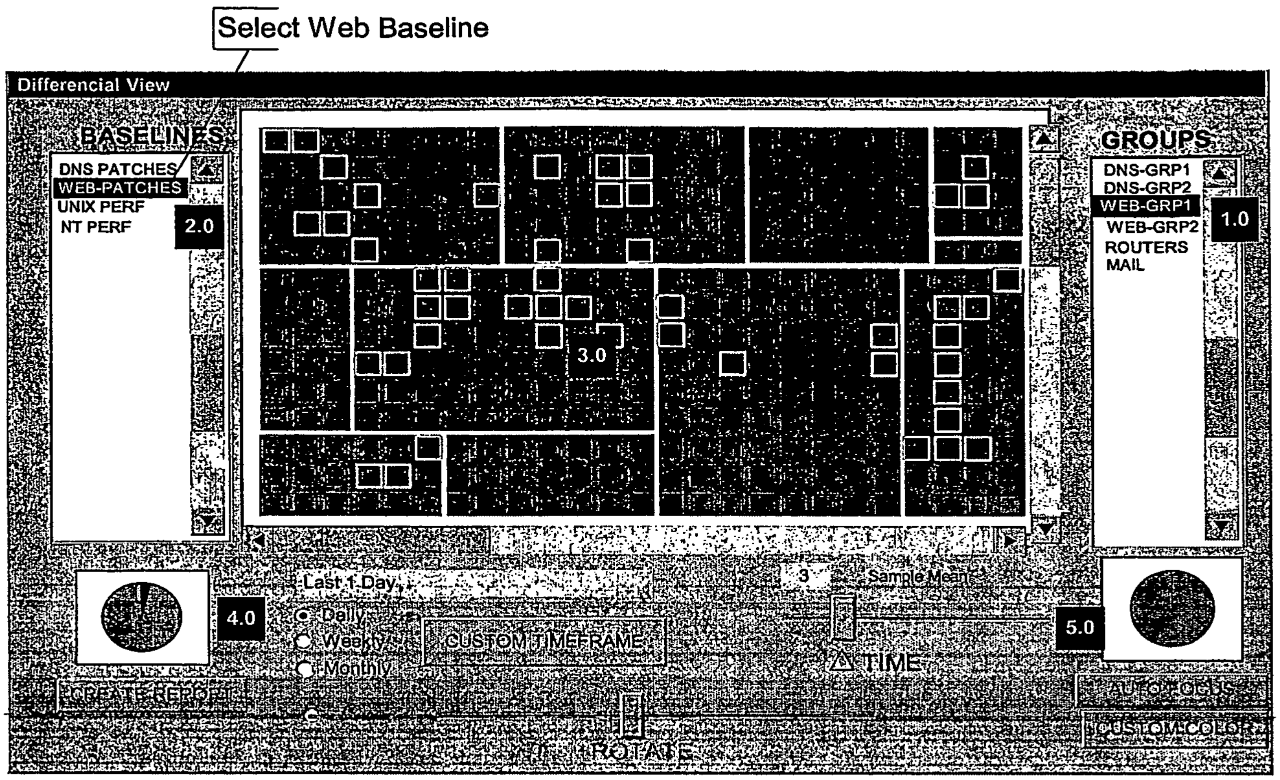

Select Web Baseline
Differencial View
BASELINES
DNS PATCHES
WEB-PATCHES
UNIX PERF
NT PERF
2.0
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
1.0
3.0
4.0
Last 1 Day
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
3
Sample Mean
TIME
5.0
ROTATE

Figure 3

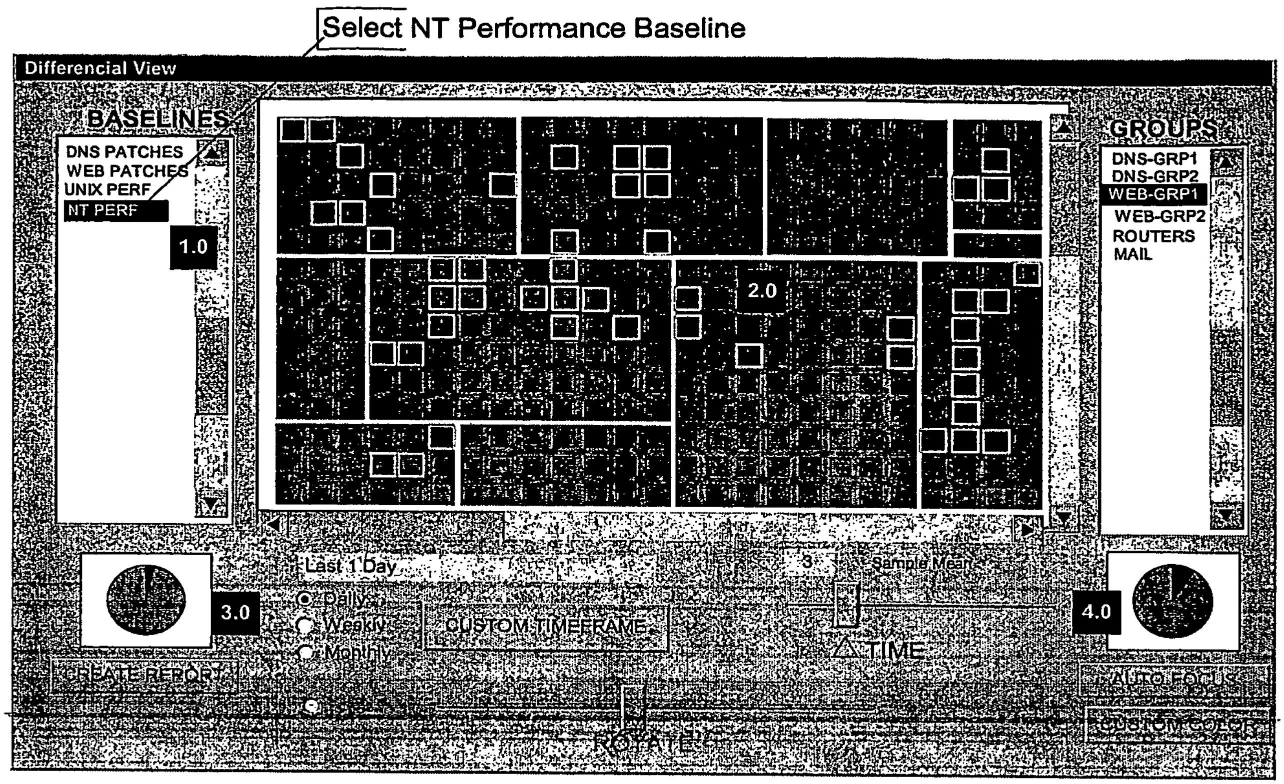

Select NT Performance Baseline
Differencial View
BASELINES
DNS PATCHES
WEB PATCHES
UNIX PERF
NT PERF
1.0
2.0
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
3.0
Last 1 Day
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
3
Sample Mean
△TIME
4.0
CREATE REPORT
AUTO FOCUS
CUSTOM COLOR
ROTATE

Figure 4

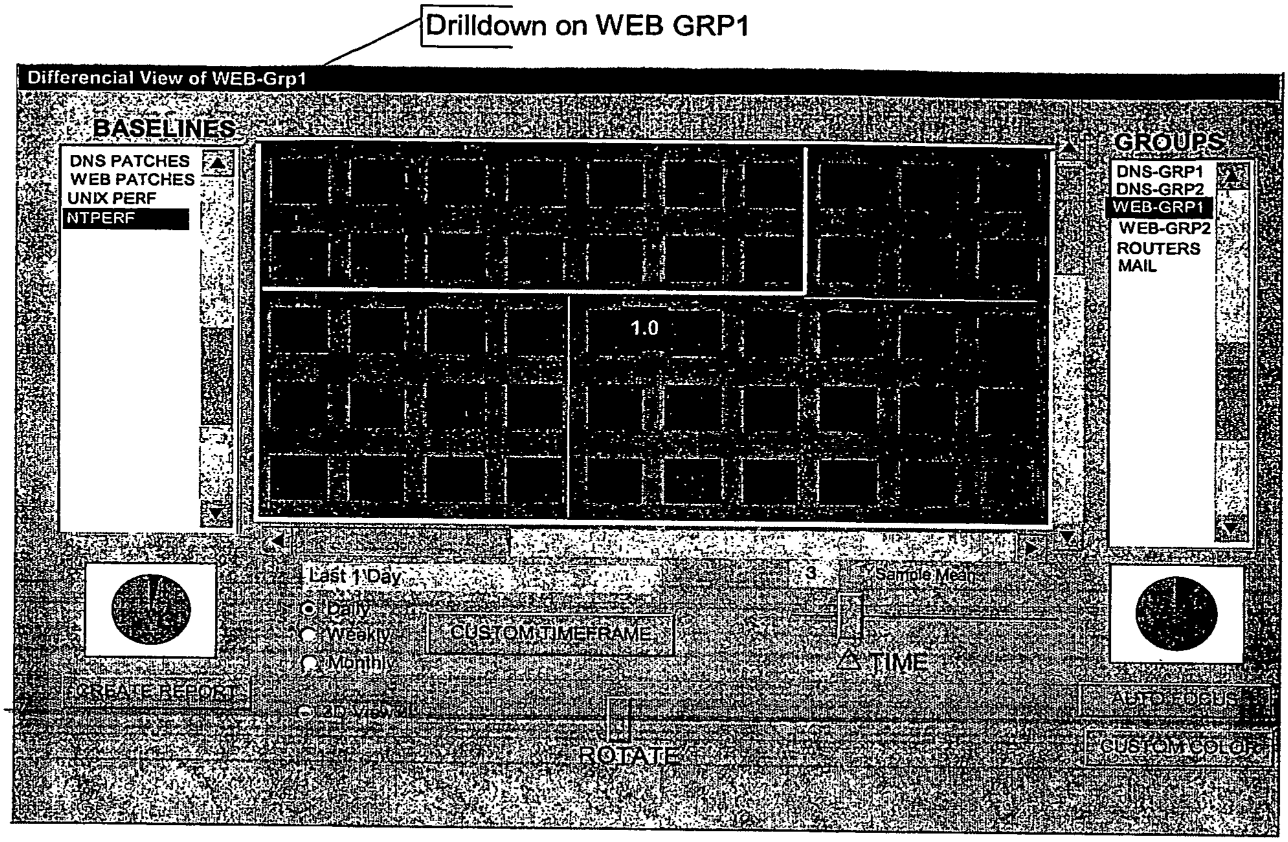
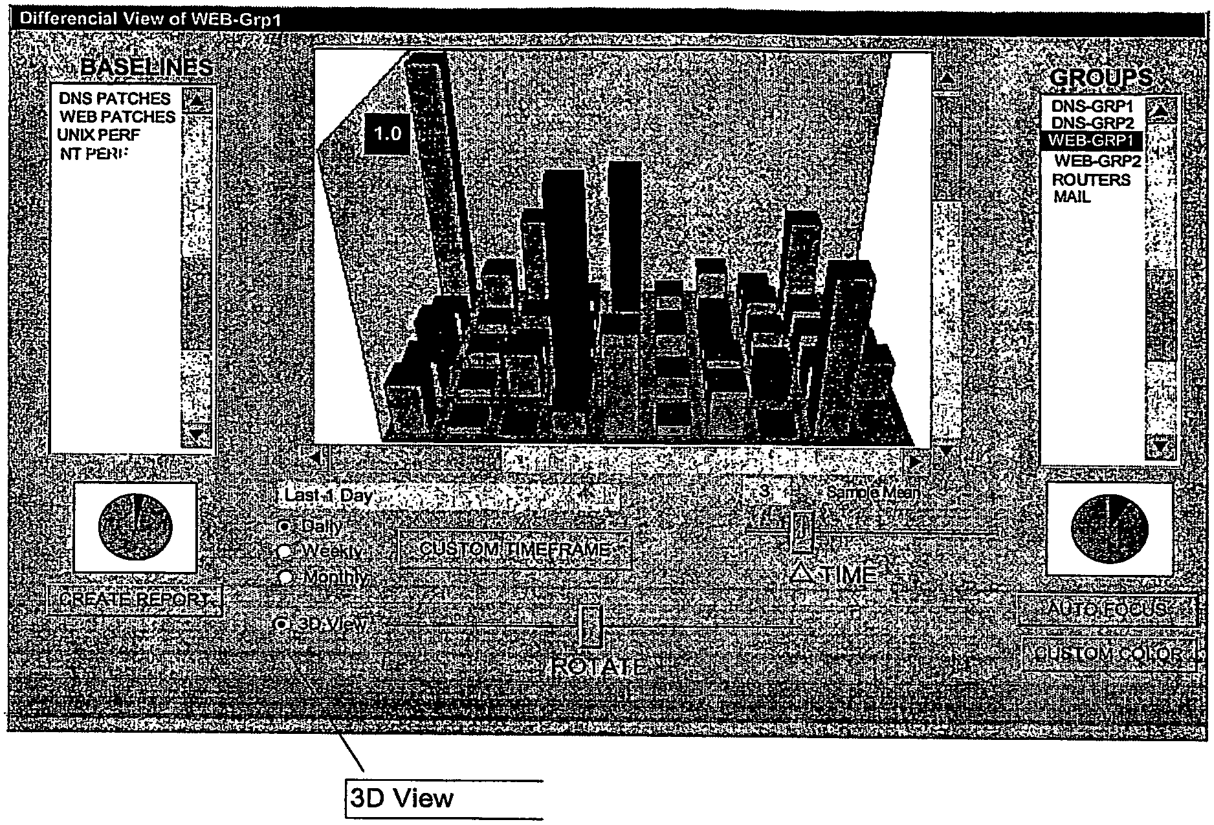

Drilldown on WEB GRP1
Differencial View of WEB-Grp1
BASELINES
DNS PATCHES
WEB PATCHES
UNIX PERF
NTPERF
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
1.0
Last 1 Day
3
Sample Mean
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
TIME
CREATE REPORT
AUTO FOCUS
ROTATE
CUSTOM COLOR

Figure 5



1.– 3d View can be rotated using a gliding Rotate button.

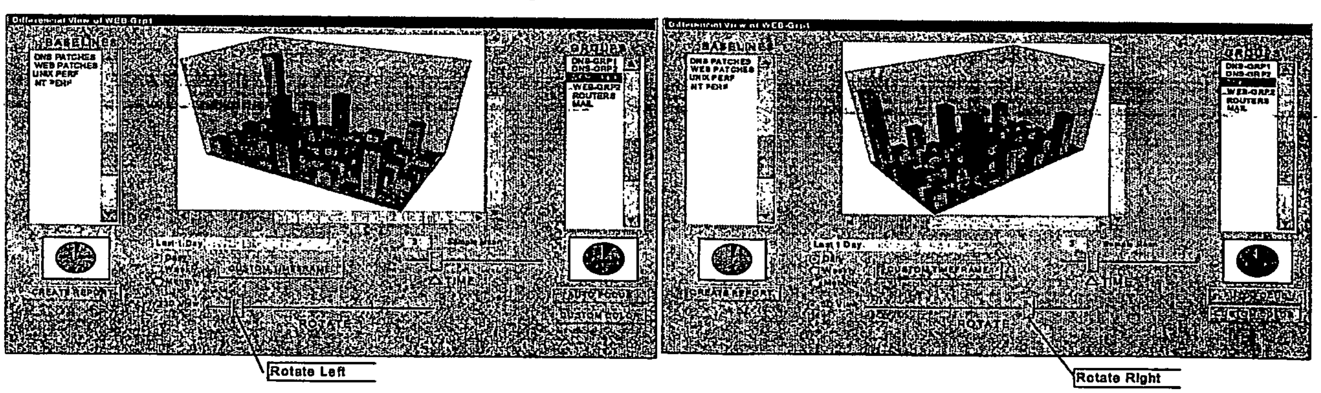


Figure 6

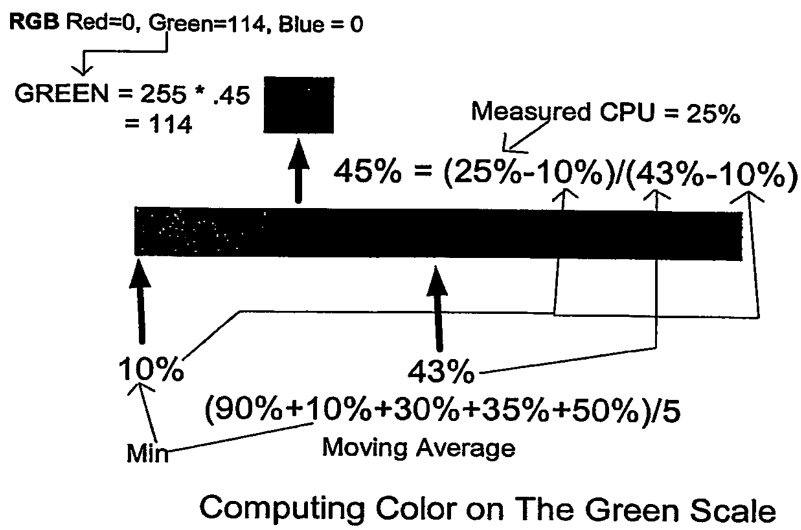

RGB Red=0, Green=114, Blue = 0
GREEN = 255 * .45
= 114
Measured CPU = 25%
45% = (25%-10%)/(43%-10%)
10%
43%
(90%+10%+30%+35%+50%)/5
Min
Moving Average
Computing Color on The Green Scale

Figure 7

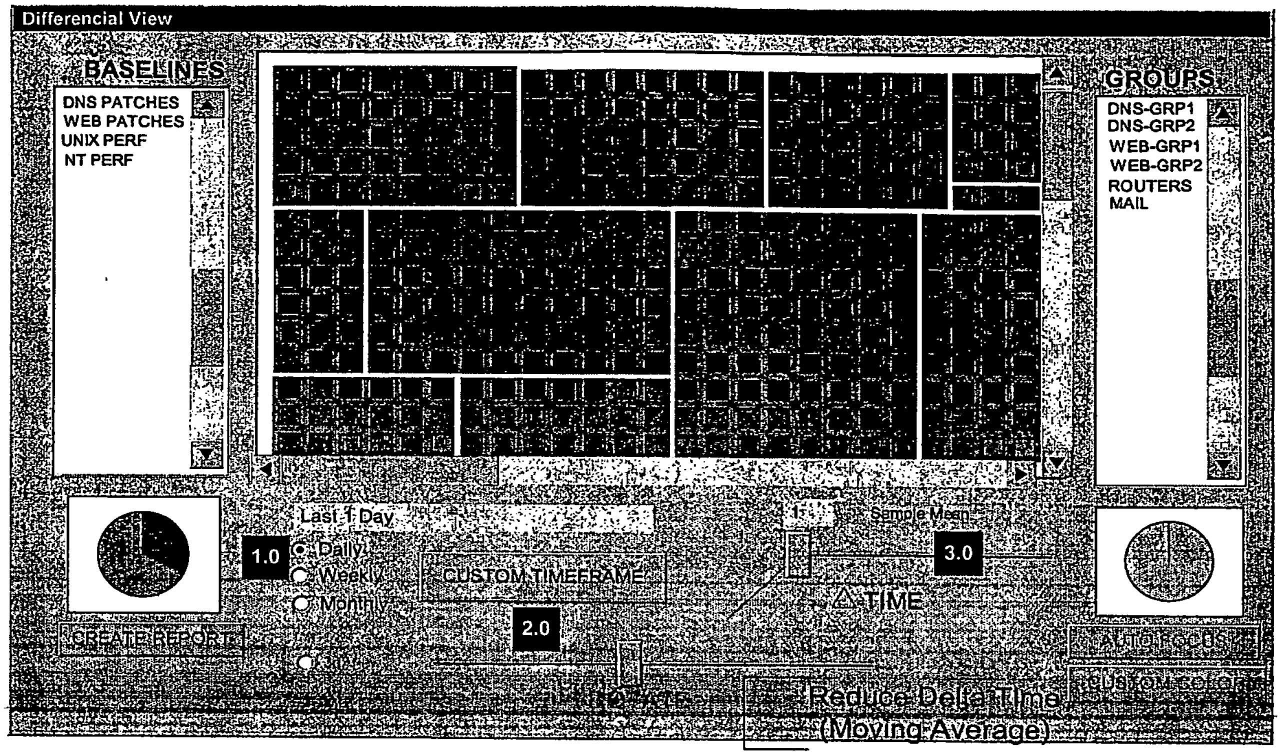

Differencial View
BASELINES
DNS PATCHES
WEB PATCHES
UNIX PERF
NT PERF
GROUPS
DNS-GRP1
DNS-GRP2
WEB-GRP1
WEB-GRP2
ROUTERS
MAIL
Last 1 Day
1.0
Daily
Weekly
Monthly
CUSTOM TIMEFRAME
2.0
Sample Mean
3.0
TIME
CREATE REPORT
AUTO FOCUS
Reduce Delta Time
(Moving Average)

Figure 8

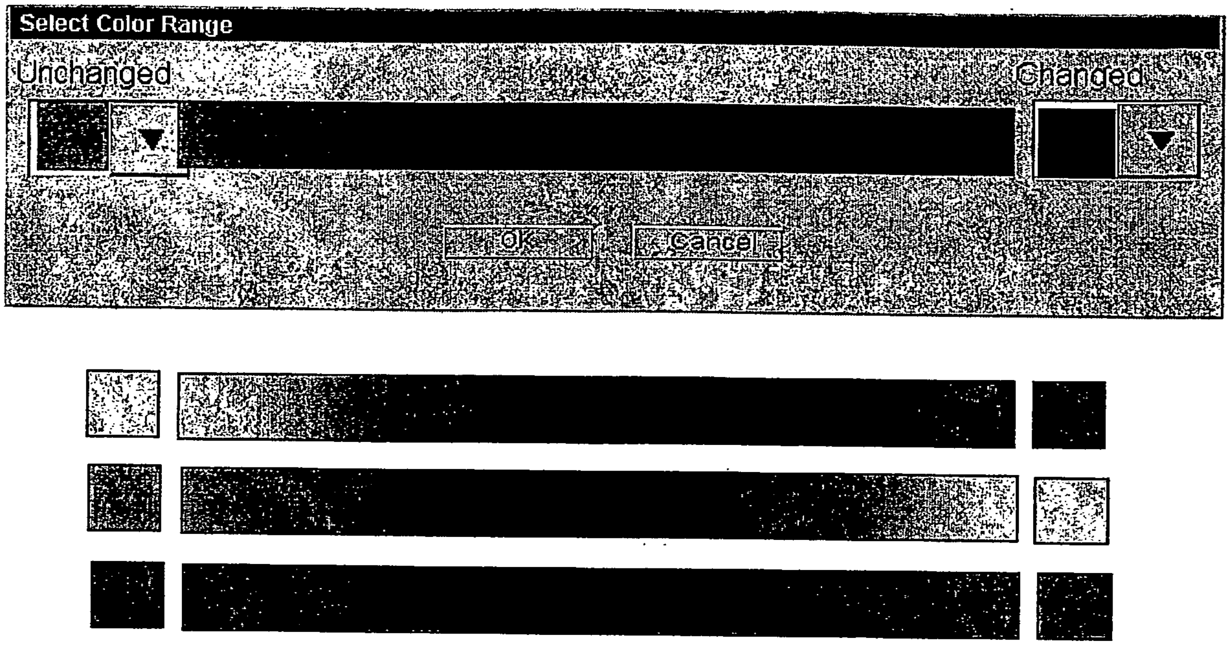


Figure 9

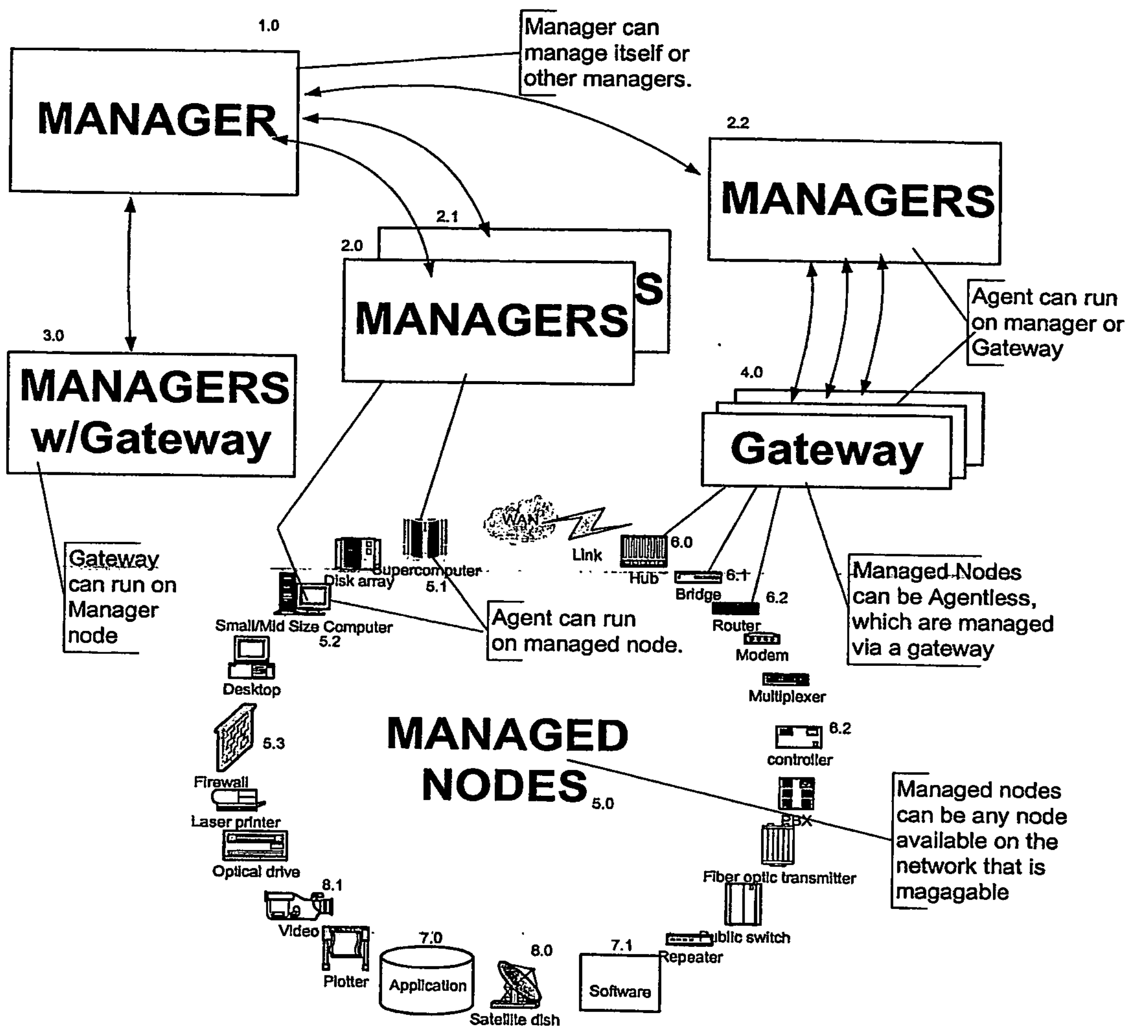

1.0
MANAGER
Manager can manage itself or other managers.
2.2
MANAGERS
2.1
2.0
MANAGERS
3.0
MANAGERS w/Gateway
Agent can run on manager or Gateway
4.0
Gateway
Gateway can run on Manager node
WAN
Link
6.0
Hub
Disk array
Supercomputer
5.1
6.1
Bridge
6.2
Router
Modem
Small/Mid Size Computer
5.2
Agent can run on managed node.
Managed Nodes can be Agentless, which are managed via a gateway
Desktop
Multiplexer
5.3
Firewall
MANAGED NODES
5.0
6.2
controller
PBX
Managed nodes can be any node available on the network that is magagable
Laser printer
Optical drive
8.1
Video
Fiber optic transmitter
Plotter
7.0
Application
8.0
Satellite dish
7.1
Software
Public switch
Repeater

Figure 10